Department of Biomedical Engineering

Chair: Jianyi Zhang, MD, PhD
Associate Chair of Education: Alan Eberhardt, PhD

Degree Offered: Bachelor of Science in Biomedical Engineering
Accreditation: The Bachelor of Science in Biomedical Engineering degree program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.
Website: https://www.uab.edu/engineering/bme/undergraduate
Program Director: Alan Eberhardt, PhD
Email: aeberhar@uab.edu
Phone: 205-934-8420

Biomedical engineering (BME) is the application of engineering principles and technology to the solution of problems in the life sciences and medicine. Biomedical engineers create knowledge and develop technologies that improve healthcare delivery and patient outcomes with an emphasis on reducing healthcare costs. Graduates create and apply knowledge at the interface of life sciences and engineering for the benefit of society. The BME undergraduate program prepares graduates to be immediately productive and able to adapt to a rapidly changing environment. The curriculum includes engineering core courses, mathematics, calculus-based physics, biology, chemistry, humanities, social and behavioral sciences, biomedical engineering core courses and electives. The curriculum culminates in a capstone design experience where interdisciplinary teams apply knowledge to solve real-world engineering problems. A bachelor’s degree in BME from UAB provides a foundation in medical devices, biomedical implants, biomaterials, and biomedical instrumentation to compete in an increasingly technical medical field, and also prepares students for graduate school, medical school, or professional school.

Admission

Freshmen with an ACT score of 28 or higher (or SAT equivalent) and a high school GPA of 3.00 or higher may be admitted directly to the Biomedical Engineering program. Please refer to the School of Engineering overview for policies regarding admission; change of major; transfer credit; transient status; dual degree programs; reasonable progress; academic warning, probation, and suspension; reinstatement appeals; and graduation requirements.

Academic Warning, Probation, and Readmission

BME students must maintain an institutional (UAB) GPA of at least 2.50. First-term BME freshmen students who have an institutional GPA below 2.50 will be placed on academic warning in BME. If their institutional GPA is not at least 2.50 after the next term enrolled, they will be placed on academic probation in BME. BME undergraduates (other than first-term freshmen) who do not have an institutional GPA of at least 2.50 will be placed on academic probation. If at the end of the next term in which they enroll, their institutional GPA is not at least 2.50, they will be reclassified as Pre-Engineering. To be re-admitted to the BME program, a student must have an institutional GPA of at least 3.00 and make a formal application for readmission.

Program and Graduation Requirements

BME students must have an institutional GPA of at least 2.50 and have completed at least 64 hours of coursework applicable to their degree before they may register for 300-level and 400-level BME courses. BME students must also have an institutional GPA of 2.50 or higher and have earned a grade of C or better in all BME courses to graduate.

Non-Majors Enrolled in BME Coursework

In addition to fulfilling course prerequisites, non-BME students (including pre-BME students and students seeking a BME minor) who wish to enroll in 300-level and 400-level BME courses must have an institutional (UAB) GPA of at least 3.00 or permission of the BME Undergraduate Advisor. Non-BME majors may not enroll in BME 423, BME 498, or BME 499.

BME Minors

Please refer to the Minors tab on the School of Engineering’s Overview page in this catalog for information specific to BME minors.

Vision

To be an internationally recognized, research-oriented Department of Biomedical Engineering; a top choice for undergraduate and graduate education.

Mission

The Department of Biomedical Engineering provides leadership in teaching the principles of engineering and biology and in conducting research that will translate new discoveries in biological engineering science to the fields of public health and clinical medicine. These efforts will enable us to identify new solutions to critical challenges in health care and the life sciences.

Program Educational Objectives

Graduates of the Biomedical Engineering undergraduate program will have:

1. Gained admission to graduate or professional school, or gained employment in engineering and/or health related professions and service
2. Pursued opportunities for professional growth, development, and service

Student Outcomes

Upon completion of the BSBME degree program, our graduates will have:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Bachelor of Science in Biomedical Engineering

Major in Biomedical Engineering

Requirements Hours

Core Curriculum as Specified for Engineering Majors 36

Area I: Written Composition (6 hrs)

Area II: Humanities and Fine Arts (9 hrs)

Area III: Natural Sciences and Mathematics (12 hrs)

Area IV: History, Social, and Behavioral Sciences (9 hrs)

Other Required Courses 80

BME 210 Engineering in Biology
BME 310 Biomaterials
BME 312 Biocomputing
BME 313 Bioinstrumentation
BME 333 Biomechanics of Solids
BME 340 Bioimaging
BME 350 Biological Transport Phenomena
BME 401 Undergraduate Biomedical Engineering Seminar
BME 423 Living Systems Analysis and Biostatistics
BME 498 Capstone Design I Product Development
BME 499 Capstone Design II

BY 123 Introductory Biology I
& 123L and Introductory Biology I Laboratory

BY 210 Genetics

BY 409 Principles of Human Physiology
& 409L and Principles of Human Physiology Laboratory

CE 210 Statics

CH 115 General Chemistry I
& 115R and General Chemistry I Recitation
& CH 116 and General Chemistry I Laboratory

CH 117 General Chemistry II
& 117R and General Chemistry II Recitation
& CH 118 and General Chemistry II Laboratory

EE 312 Electrical Systems

EGR 110 Introduction to Engineering I

EGR 111 or EGR 21 Introduction to Engineering

EGR 150 Computer Methods in Engineering

EGR 265 Math Tools for Engineering Problem Solving
MA 126 Calculus II
MA 260 Introduction to Linear Algebra
ME 102 Engineering Graphics
ME 215 Dynamics
& 215R and Dynamics Recitation
MSE 280 Engineering Materials

Biomedical Engineering Electives 6

BME 420 Implant-Tissue Interactions
BME 435 Tissue Engineering
BME 443 Medical Image Processing
BME 450 Computational Neuroscience
BME 461 Bioelectric Phenomena
BME 462 Cardiac Electrophysiology
BME 471 Continuum Mechanics of Solids
BME 472 Industrial Bioprocessing and Biomanufacturing
BME 490 Special Topics in Biomedical Engineering
BME 491 Individual Study in Biomedical Engineering 1
BME 494 Honors Research I 1, 2

Engineering/Math/Science Electives 3 6

Select six credit hours from the following or from the list of Biomedical Engineering electives above

BY 271 Biology of Microorganisms
& 271L and Biology of Microorganisms Laboratory
BY 280 Biology of Aging
BY 311 Molecular Genetics
BY 330 Cell Biology
BY 362 Neurobiology
CE 337 Hydraulics
CE 345 Transportation Engineering
CE 360 Structural Analysis
CE 395 Engineering Economics
CE 420 Advanced Mechanics
CE 433 Solid and Hazardous Wastes Management
CH 235 Organic Chemistry I
& 235R and Organic Chemistry I Recitation
CH 237 Organic Chemistry II
& 237R and Organic Chemistry II Recitation
CH 355 Quantitative Analysis
CH 460 Fundamentals of Biochemistry
MA 313 Patterns, Functions and Algebraic Reasoning
MA 360 Scientific Programming
MA 361 Mathematical Modeling
MA 453 Transforms
MA 485 Probability
ME 360 Introduction to Mechatronic Systems Engineering
ME 370 Kinematics and Dynamics of Machinery
ME 371 Machine Design
ME 464 Introduction to Finite Element Method
MSE 281 Physical Materials I
& 281L and Physical Materials I Laboratory
MSE 380 Thermodynamics of Materials
MSE 401 Materials Processing
MSE 430 Polymeric Materials
& 430L and Polymeric Materials Laboratory
PH 475 Introduction to Biophysics I
PH 487 Nanoscale Science and Applications
**Concentration in Biomechanics**

Students seeking the degree of BSBME may add a concentration in Biomechanics by appropriate selection of their Mathematics/Science/Engineering Electives (3 credit hours), Engineering Elective (3 credit hours), and BME Electives (6 credit hours).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>BME 408 Advanced Biological Transport Phenomena</td>
<td>3</td>
</tr>
<tr>
<td>BME 417 Engineering Analysis</td>
<td>3</td>
</tr>
<tr>
<td>BME 471 Continuum Mechanics of Solids</td>
<td>3</td>
</tr>
<tr>
<td>ME 464 Introduction to Finite Element Method</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>12</strong></td>
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</table>

**Concentration in Biomaterials/Tissue Engineering**

Students seeking the degree of BSBME may add a concentration in Biomaterials/Tissue Engineering by appropriate selections of their Mathematics/Science/Engineering Elective (3 credit hours), Engineering Elective (3 credit hours), and BME Electives (6 credit hours).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 420 Implant-Tissue Interactions</td>
<td>3</td>
</tr>
<tr>
<td>BME 435 Tissue Engineering</td>
<td>3</td>
</tr>
<tr>
<td>MSE 281 Physical Materials I</td>
<td>4</td>
</tr>
<tr>
<td><strong>Elective Courses</strong></td>
<td><strong>3</strong></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td></td>
</tr>
<tr>
<td>BY 311 Molecular Genetics</td>
<td></td>
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<td>BY 330 Cell Biology</td>
<td></td>
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<tr>
<td>BY 431 Principles of DNA Technology</td>
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<tr>
<td>MSE 381 Physical Materials II</td>
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<tr>
<td>MSE 382 Mechanical Behavior of Materials</td>
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<tr>
<td>MSE 401 Materials Processing</td>
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<tr>
<td>MSE 408 Nanobiomaterials</td>
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<tr>
<td>MSE 413 Composite Materials</td>
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<tr>
<td>MSE 430 Polymeric Materials</td>
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<tr>
<td>MSE 464 Metals and Alloys</td>
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<td>MSE 470 Ceramic Materials</td>
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<tr>
<td>MSE 484 Electronic, Magnetic, and Thermal Prop of Materials</td>
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<tr>
<td>PH 487 Nanoscale Science and Applications</td>
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<tr>
<td><strong>Total Hours</strong></td>
<td><strong>13</strong></td>
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</tbody>
</table>

Please refer to the School of Engineering Overview for School policies related to admission, academic progress, reasonable progress toward degree, and graduation.

Curriculum for the Bachelor of Science in Biomedical Engineering (BSBME)

<table>
<thead>
<tr>
<th>Freshman First Term</th>
<th>Hours</th>
<th>Second Term First Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 115 &amp; 115R &amp; CH 116 &amp; EGR 110</td>
<td>4</td>
<td>BY 123 &amp; CH 117</td>
<td>4</td>
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<tr>
<td><strong>Total Hours</strong></td>
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<table>
<thead>
<tr>
<th>Sophomore First Term</th>
<th>Hours</th>
<th>Second Term First Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BY 210 &amp; EGR 265 &amp; PH 221 &amp; EGR 111</td>
<td>3</td>
<td>EGR 150 &amp; BY 210 &amp; CE 210</td>
<td>3</td>
</tr>
<tr>
<td>MA 260 &amp; MSE 280</td>
<td>3</td>
<td>PH 312 &amp; MSE 280</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>16</strong></td>
<td></td>
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</tbody>
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<table>
<thead>
<tr>
<th>Junior First Term</th>
<th>Hours</th>
<th>Second Term First Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BME 310 &amp; BME 312 &amp; BME 313 &amp; BY 409</td>
<td>3</td>
<td>BME 333 &amp; BME 340 &amp; BME 350</td>
<td>3</td>
</tr>
<tr>
<td>ME 215</td>
<td>3</td>
<td>Core Curriculum Area II: Humanities and Fine Art</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>17</strong></td>
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<table>
<thead>
<tr>
<th>Senior First Term</th>
<th>Hours</th>
<th>Second Term First Term</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>BME 498 &amp; BME 401</td>
<td>3</td>
<td>BME 499 &amp; 1 Biomedical Engineering Elective</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>16</strong></td>
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</tbody>
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Note: AP credit may be used for elective credit. Core Curriculum Area II: Humanities and Fine Art. Core Curriculum Area IV: History, Social, and Behavioral Science.
BME Elective 3

Total credit hours: 128

1. Transfer students may substitute EGR 200 for EGR 110 and EGR 111.
3. Students using this curriculum as a pre-health professional program (pre-med, pre-dental, or pre-optometry) may use CH 235 or CH 237 or CH 460 for this elective.
4. Please refer to the Core Curriculum as specified for engineering majors.
5. Seminar may be taken during any semester.

Courses

BME 011. Undergraduate Coop/Internship in BME. 0 Hours.
Engineering workplace experience in preparation for the student's intended career.

BME 210. Engineering in Biology. 3 Hours.
Application of engineering to the study of biology on the cellular and molecular level. Engineering solutions in genomics, proteomics, and nanotechnology to investigate cellular and molecular process.
Prerequisites: BY 123 [Min Grade: C] and PH 222 [Min Grade: C] (Can be taken Concurrently) and BY 210 [Min Grade: C] (Can be taken Concurrently)

BME 289. Undergraduate Research in Biomedical Engineering I. 1 Hour.
Undergraduate research experiences in biomedical engineering. Must have sophomore standing.
Prerequisites: EGR 200 [Min Grade: C] or EGR 111 [Min Grade: C] or HC 111 [Min Grade: C] and MA 125 [Min Grade: C] or MA 225 [Min Grade: C] or MA 227 [Min Grade: C] and PH 221 [Min Grade: C] (Can be taken Concurrently)

BME 310. Biomaterials. 3 Hours.
Introduction to wide range of materials used for biomedical applications. Physical, chemical and mechanical properties of biomaterials.
Prerequisites: MSE 280 [Min Grade: C] and BME 210 [Min Grade: C]

BME 311. Biomaterials for Non-Majors. 3 Hours.
Wide range of materials used for biomedical applications. Physical, chemical and mechanical properties of biomaterials.
Prerequisites: MSE 280 [Min Grade: C]

BME 312. Biocomputing. 3 Hours.
Introduction to computational techniques used in biomedical engineering.
Prerequisites: EGR 150 [Min Grade: C] and EGR 265 [Min Grade: C] or MA 227 [Min Grade: C] and MA 252 [Min Grade: C] and MA 260 [Min Grade: C] (Can be taken Concurrently)

BME 313. Bioinstrumentation. 3 Hours.
An introduction to instrumentation used to make biological and physiological measurements. Techniques include acquisition and analysis of bioelectric signals and instrument control.
Prerequisites: EE 312 [Min Grade: C] and (MA 227 [Min Grade: C] and MA 252 [Min Grade: C] or EGR 265 [Min Grade: C])

BME 333. Biomechanics of Solids. 3 Hours.
Application of mechanics of solids principles to biomedical engineering problems; stress-strain of bone, viscoelasticity and constitutive equations of tissues, mechanics of the cell, introduction to molecular mechanics.
Prerequisites: EGR 265 [Min Grade: C] (Can be taken Concurrently) or MA 227 [Min Grade: C] (Can be taken Concurrently) and MA 252 [Min Grade: C] (Can be taken Concurrently) and CE 210 [Min Grade: C]

BME 340. Bioimaging. 3 Hours.
Overview of diagnostic imaging including major imaging modalities such as X-Ray/CT, Nuclear Imaging, Ultrasound, Magnetic Resonance and in vivo molecular imaging approaches. Physical principles of image formation, image interpretation and patient safety.
Prerequisites: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and BME 210 [Min Grade: C] and EE 312 [Min Grade: C] (Can be taken Concurrently)

BME 350. Biological Transport Phenomena. 3 Hours.
Basic mechanisms and mathematical analysis of transport processes with biological and biomedical applications. Analysis of flow, transport and reaction processes for biological fluids and biological molecules with applications towards development of artificial organs, drug delivery systems and tissue engineering products.
Prerequisites: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and BME 210 [Min Grade: C] (Can be taken Concurrently) and BY 408 [Min Grade: C] (Can be taken Concurrently) and ME 215 [Min Grade: C] (Can be taken Concurrently)

BME 389. Undergraduate Research in Biomedical Engineering II. 1 Hour.
Undergraduate research experiences in biomedical engineering. Must have junior standing.
Prerequisites: BME 210 [Min Grade: C]

BME 401. Undergraduate Biomedical Engineering Seminar. 1 Hour.
Undergraduate seminar.

BME 420. Implant-Tissue Interactions. 3 Hours.
An overview of implant biocompatibility including tissue histology, histopathology of implant response and the regulatory process for medical devices. Emphasis placed on ethical issues related to design, development, and implementation of biomedical implants. Ethics and Civic Responsibility are significant components of this course.
Prerequisites: BME 310 [Min Grade: C] or BME 311 [Min Grade: C]

BME 423. Living Systems Analysis and Biostatistics. 3 Hours.
Basic concepts and techniques of measurement processing and analysis of data from living systems. Statistics, analysis of variance and regression analysis. Emphasis is placed on data analysis and presentation of group projects.
Prerequisites: BME 312 [Min Grade: C]

BME 424. Current Topics in Stem Cell Engineering. 3 Hours.
This course is designed for students interested in the field of stem cells, regenerative medicine, and tissue engineering using stem cells and stem cell derived cells. The course will introduce the role of stem cells in tissue growth and development, the theory behind the design and in vitro construction of tissue and organ replacements, and the applications of biomedical engineering principles to the treatment of tissue-specific diseases. Students will have hands on experience on culturing and analyzing stem cells, stem cell differentiation, analysis of functional and physiological properties of differentiated cells, and fabricating basic engineered-tissues.
Prerequisites: BY 123 [Min Grade: C] and BY 210 [Min Grade: C]
BME 435. Tissue Engineering. 3 Hours.
Principles underlying strategies for regenerative medicine such as stem-cell based therapy, scaffold design, proteins or genes delivery, roles of extracellular matrix, cell-materials interactions, angiogenesis, tissue transplantation, mechanical stimulus and nanotechnology.
Prerequisites: BME 310 [Min Grade: C] or BME 311 [Min Grade: C]

BME 443. Medical Image Processing. 3 Hours.
Fundamental topics of medical image processing to practical applications using conventional computer software.
Prerequisites: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] or MA 252 [Min Grade: C]) and PH 222 [Min Grade: C]

BME 450. Computational Neuroscience. 3 Hours.
This course examines the computational principles used by the nervous system. Topics include: biophysics of axon and synapse, sensory coding (with an emphasis on vision and audition), planning and decision-making, and synthesis of motor responses. There will be an emphasis on systems approach throughout. Homework includes simulations.
Prerequisites: BME 312 [Min Grade: C]

BME 461. Bioelectric Phenomena. 3 Hours.
Quantitative methods in electrophysiology with focus on using simulations to examine responses in electrically excitable cell types.
Prerequisites: BME 312 [Min Grade: C]

BME 462. Cardiac Electrophysiology. 3 Hours.
Experimental and computational method on cardiac electrophysiology, ionic current, action potentials, electrical propagation, the electrocardiogram, electromechanical coupling, cardiac arrhythmias, effects of electric fields in cardiac tissue, defibrillation and ablation.
Prerequisites: BME 312 [Min Grade: C]

BME 471. Continuum Mechanics of Solids. 3 Hours.
Matrix and tensor mathematics, fundamentals of stress, momentum principles, Cauchy and Piola-Kirchoff stress tensors, static equilibrium, invariance, measures of strain, Lagrangian and Eulerian formulations, Green and Almansi strain, deformation gradient tensor, infinitesimal strain, constitutive equations, finite strain elasticity, strain energy methods, 2-D Elasticity, Airy Method, viscoelasticity, mechanical behavior of polymers.
Prerequisites: EGR 265 [Min Grade: C] or (MA 227 [Min Grade: C] and MA 252 [Min Grade: C]) and (BME 333 [Min Grade: C] or CE 220 [Min Grade: C])

BME 472. Industrial Bioprocessing and Biomanufacturing. 3 Hours.
This course will introduce students to the growing industries related to biomedical, biopharmaceutical and biotechnology. It is targeted to offer the students marketable skills to work in a vital area of economic growth and also convey some of the challenges and opportunities awaiting.
Prerequisites: BME 310 [Min Grade: C](Can be taken Concurrently) or BY 330 [Min Grade: C](Can be taken Concurrently) or CH 460 [Min Grade: C](Can be taken Concurrently)

BME 489. Undergraduate Research in Biomedical Engineering. 1-3 Hour.
Undergraduate research experiences in biomedical engineering.
Prerequisites: BME 210 [Min Grade: C]

BME 490. Special Topics in Biomedical Engineering. 1-3 Hour.
Special Topic in Biomedical Engineering.

BME 491. Individual Study in Biomedical Engineering. 1-6 Hour.
Individual Study in Biomedical Engineering.

BME 494. Honors Research I. 1-3 Hour.
Research experiences for undergraduates enrolled in the departmental honors program. The student should write a proposal and make a presentation based on the proposal.
Prerequisites: EGR 301 [Min Grade: C] or STH 201 [Min Grade: C]

BME 495. Honors Research II. 1-3 Hour.
Research opportunities for undergraduate students in the Biomedical Engineering Honors Program. Research areas include cardiac electrophysiology, brain imaging, biomedical implants, and tissue engineering.
Prerequisites: BME 494 [Min Grade: C]

BME 496. Biomedical Engineering Honors Seminar. 1 Hour.
Must be enrolled in an Honors Program.

BME 498. Capstone Design I Product Development. 3 Hours.
Design and development of medical-products. Through experiential learning, students go through the early phases of engineering design innovation for medical products, starting with clinical immersion to determine a critical health-care need. Engineering students work in multi-disciplinary teams that include students from the School of Business to develop design concepts for both a client-based prototype and a commercializable version. Designs take into account client needs as well as legal, regulatory, and marketing requirements. Business ethics are also covered. Emphasis is placed on communication in both oral and written format to targeted audiences.
Prerequisites: BME 310 [Min Grade: C](Can be taken Concurrently) and BME 312 [Min Grade: C](Can be taken Concurrently) and BME 313 [Min Grade: C](Can be taken Concurrently)

BME 499. Capstone Design II. 3 Hours.
Capstone design project; a continuation of BME 498. Through experiential learning, student teams complete the engineering design process for their client-based prototype incorporating engineering standards and realistic constraints. Student teams develop a business plan to present to potential business partners and product development teams from established companies. Additional skills learned in this part of the design process include: development of business proposals, project planning and scheduling, project execution and resource scheduling, communication of design, and interim and final design reviews. Emphasis is placed on communication of design and design justification in both an oral and written format to targeted audiences.
Prerequisites: BME 498 [Min Grade: C] and ME 102 [Min Grade: C]